

**(19) World Intellectual Property Organization  
International Bureau**



**(43) International Publication Date**  
**24 July 2003 (24.07.2003)**

**PCT**

**(10) International Publication Number**  
**WO 03/061117 A1**

**(51) International Patent Classification<sup>7</sup>: H03F 3/217**

**(21) International Application Number:** PCT/PL03/00006

**(22) International Filing Date:** 18 January 2003 (18.01.2003)

(25) Filing Language: English

(26) Publication Language: English

**(30) Priority Data:**  
P-351783      21 January 2002 (21.01.2002)      PL

**(71) Applicants (for all designated States except US): ADVANCED DIGITAL BROADCAST POLSKA SP. Z.O.O. [PL/PL]; ul. Trasa Północna 16, PL-65-119 Zielona Góra (PL). ADVANCED DIGITAL BROADCAST LTD. [—/—]; 8/F, 145 Chung Shan North Road, Section 2, Taipei 104 Taiwan (TW).**

**(72) Inventor; and**

**(75) Inventor/Applicant (for US only): HANZLIK, Tomasz**  
[PL/PL]; ul. Szybowa 16/152, 54-130 Wrocław (PL).

**(74) Agent: HUDY, Ludwik; Czernichów 4, PL-32-070 Czernichów, Kraków (PL).**

**(81) Designated States (national):** AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PT, RO, RU, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

**(84) Designated States (regional):** ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

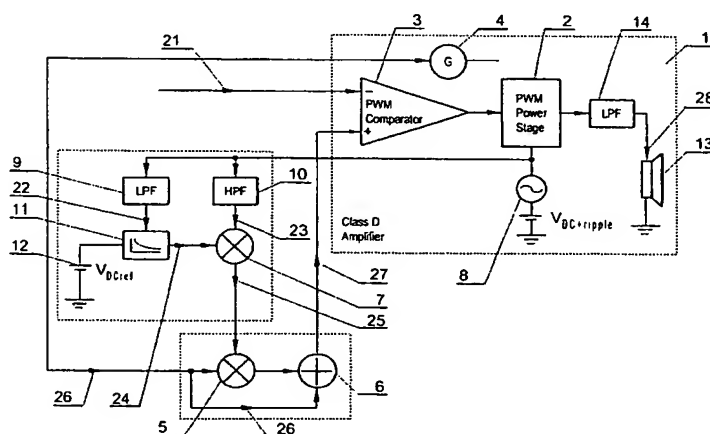
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for all designations*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*
- *of inventorship (Rule 4.17(iv)) for US only*

**Published:**

- with international search report

*[Continued on next page]*

**(54) Title:** CLASS D ELECTROACOUSTIC AMPLIFIER AND METHOD FOR COMPENSATION OF POWER SUPPLY VOLTAGE INFLUENCE ON OUTPUT AUDIO SIGNAL IN CLASS D ELECTROACOUSTIC AMPLIFIER



**(S7) Abstract:** In a class D electroacoustic amplifier (1) without feedback loop containing a supply voltage source (8), an amplifier low-pass filter (14), a power stage (2) controlled by a pulse width modulated signal, a saw-shaped voltage generator (4) and a comparator (3), to one of which inputs an audio signal is sent, while its second input is connected to the adder (6) of the compensation circuit of supply voltage influence on the output audio signal, to which a voltage from a reference voltage source is sent, a low-pass filter (9) and a high-pass filter (10) are connected to the supply voltage source (8), and the reference voltage source (12) is connected to an inverting circuit (11), whose input is connected to the low-pass filter (9) output, while the high-pass filter (10) output and the output of the inverting circuit (11) are connected to a multiplier (7), whose output is connected to the input of another multiplier (5), whose second input is connected to the saw-shaped voltage generator (4), and the multiplier (5) output is connected to one input of the adder (6) whose second input is connected to the saw-shaped voltage generator (4).



— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# CLASS D ELECTROACOUSTIC AMPLIFIER AND METHOD FOR COMPENSATION OF POWER SUPPLY VOLTAGE INFLUENCE ON OUTPUT AUDIO SIGNAL IN CLASS D ELECTROACOUSTIC AMPLIFIER

## TECHNICAL FIELD

The invention relates to a class D electroacoustic amplifier, i.e. a class D audio amplifier, and a method for compensation of power supply voltage influence on an output audio signal in the class D electroacoustic amplifier.

## BACKGROUND ART

One of the features of class D electroacoustic amplifiers is making use of a carrier signal apart from the audio signal. One of these amplifiers is the one known from the US patent No. 4,182,992, which consists of, among others, two transistors and a diode.

In turn, from the US patent No. 4,178,556 there is known a class D amplifying circuit that contains a modulating circuit to modulate an audio signal and a carrier signal.

There is also known, from the US patent No. 6,300,825 an amplifier that makes use of pulse width modulation of a signal, containing a comparator and an integrating circuit, which in order to increase the coefficient of rejection of supply voltage fluctuations, was supplemented with another integrating circuit.

From the Polish patent description P-325207 there is known a circuit for compensation of the constant component of the output voltage, powered by a stabilised voltage that generates a voltage compensation signal. This signal is added in an adder to a voltage signal of a triangular wave generator and in this way it changes the constant component of the output signal of the generator. The changed constant component influences the value of the duty cycle coefficient of the rectangular impulses generated at the output of the comparator, compensating to a degree the supply voltage fluctuations.

## DISCLOSURE OF INVENTION

According to the present invention, in a class D electroacoustic amplifier, i.e. a class D audio amplifier, without feedback loop that contains a supply voltage source, an amplifier low-pass filter, a power stage controlled by a pulse width modulated signal, a saw-shaped voltage generator and a comparator, to one of which inputs an audio signal is sent, while its second input is connected to the adder of the compensation circuit of supply voltage influence on the output audio signal, to which a voltage from a reference voltage source is sent, a low-pass filter and a high-pass filter are connected to the supply voltage source, and the reference voltage source is connected to an inverting circuit, whose input is connected to the low-pass filter output, while the high-pass filter output and the output of the inverting circuit are connected to a multiplier, whose output is connected to the input of another multiplier, whose second input is connected to the saw-shaped voltage generator, and the multiplier output is connected to one input of the adder, whose second input is connected to the saw-shaped voltage generator.

Preferably, the output signal  $v_o(t)$  of the inverting circuit sent to the multiplier input, which is a modified constant of the supply voltage, is expressed by a formula  $v_o(t) = k_1 \times V_{DCref} / [k_2 \times v_i(t)]$ , where  $V_{DCref}$  is the voltage of the reference source,  $v_i(t)$  is a slow-changing signal on the low-pass filter output, and the coefficient  $k_1 \in <0.5; 2.0>$  and the coefficient  $k_2 \in <0.2; 1.5>$ .

Preferably, the output signal of the multiplier, which is the error signal  $e(t)$ , sent to the multiplier, is expressed by the formula  $e(t) = k_3 \times v_o(t) \times v_{ii}(t)$ , where  $v_o(t)$  is a modified supply voltage constant,  $v_{ii}(t)$  is a fast-changing signal on the high-pass filter output, and the coefficient  $k_3 \in <0.8; 10.0>$ .

Preferably, the output signal  $V_{CM}(t)$  of the adder, which is the corrected carrier wave signal, sent to one input of the comparator, is expressed by the formula  $V_{CM}(t) = k_4 \times V_C(t) \times [1/k_5 + e(t)]$ , where  $V_C(t)$  is a high frequency carrier wave generated by the generator,  $e(t)$  is the error signal, and the coefficient  $k_4 \in <0.2; 1.5>$  and the coefficient  $k_5 \in <0.2; 3.0>$ .

The object of the invention is also a method of compensation of supply voltage influence on the output audio signal in an electroacoustic amplifier,

which contains a saw-shaped signal generator and a comparator making use of pulse width modulation, and which is powered from a power supply, and to whose input an audio signal is sent, and whose second input is connected to an adder of a compensation circuit of supply voltage influence on the output audio signal, to which a voltage from a reference voltage source is sent, from the power supply source a fast-changing signal  $v_{ii}(t)$  is extracted and a slow-changing signal  $v_i(t)$ , which is inverted and multiplied by the a value of a reference supply voltage  $V_{DCref}$ , which results in an output signal  $v_o(t)$ , which then is multiplied by a fast-changing signal  $v_{ii}(t)$ , which results in an error signal  $e(t)$ , which then is multiplied by a saw-shaped signal  $V_C(t)$  from the generator, and the resulting signal is added to a saw-shaped signal  $V_C(t)$  and as a corrected carrier wave  $V_{CM}(t)$  is sent to one of the inputs of the comparator, which makes use of pulse width modulation, and to its second input the audio signal is sent.

### BRIEF DESCRIPTION OF DRAWINGS

The object of this invention is shown in implementation examples on the enclosed drawings, where fig. 1 shows a block diagram of a class D electroacoustic amplifier with a system for compensation of influence of supply voltage fluctuations, figs. 2 and 3 show the result of computer simulation with the compensation system present and the supply voltage of 27 V, figs. 4 and 5 show the result of computer simulation without the compensation system present and with the supply voltage of 27 V, figs. 6 and 7 show the result of computer simulation with the compensation system present and with the supply voltage of 40 V, figs. 8 and 9 show the result of computer simulation without the compensation system present and with the supply voltage of 40 V.

### BEST MODE FOR CARRYING OUT THE INVENTION

The solution of the compensation system that is presented above can be applied in any desired system that contains a discrete class D audio line, and in the description it is supplemented with an electroacoustic amplifier. A class D electroacoustic amplifier 1, i.e. a class D audio amplifier, without feedback loop,

shown in fig. 1, contains a comparator 3, to whose input an audio signal is sent, and a generator 4, a power stage 2, using pulse width modulation, a supply voltage source 8, an amplifier low-pass filter 14, and a loudspeaker device being the load of the amplifier 1. In the shown amplifier 1, an audio input signal 21 and an output audio signal 28 are not included in the feedback loop and coefficient of supply voltage fluctuation influence rejection is 0 dB. So to reduce the supply voltage influence on output audio signal, the electroacoustic amplifier 1 has been supplemented with a compensation system containing a low-pass filter 9 and a high-pass filter 10, both of which are connected to a power supply voltage source 8.

The reference voltage source 12 of the compensation system is connected to an inverting circuit 11, whose input is connected to the low-pass filter 9 output. The high-pass filter 10 output and the inverting circuit 11 output are connected to a multiplier 7, whose output is connected to a multiplier 5 input, whose second input is connected to a saw-shaped or triangular-shaped voltage generator 4, while the multiplier output is connected to one of the adder 6 inputs, whose second input is connected to a saw-shaped or triangular-shaped voltage generator 4.

In the presented electroacoustic amplifier 1, with the compensation circuit of supply voltage influence on an audio output signal, the input signal 21 is sent to the '+' input of the comparator 3, where the comparison of the audio signal 21 with the carrier signal 26  $V_c(t)$ , which is a carrier wave of high frequency in the range of 40 kHz to 1 MHz, takes place.

In this system, the voltage from the power supply source 8 is sent to the low-pass filter 9 and the high-pass filter 10. From the high-pass filter 10 output, a fast-changing signal 23  $v_{ii}(t)$ , which is the separated variable component of the supply voltage, is sent to one of the multiplier 7 inputs, while the slow-changing signal  $v_i(t)$ , which is the separated constant component of the supply voltage, from the low-pass filter 9 is sent to the inverting circuit 11 input. Moreover, the voltage  $V_{DCref}$  of the reference voltage source 12 is connected to the inverting circuit 11. Then, the signal 24, given by the formula  $v_0(t) = k_1 \times V_{DCref} / [k_2 \times v_i(t)]$ , from the inverting circuit 11 output is sent to the multiplier 7

input, where the multiplying of this signal with the fast-changing signal 23 from the high-pass filter 10 output takes place, and the received error signal, expressed by the formula  $e(t) = k_3 \times v_o(t) \times v_{ii}(t)$ , from the multiplier 7 input is sent to one of the multiplier 5 inputs. In the multiplier 5, the multiplying of the carrier signal 26  $V_C(t)$  from a saw-shaped or triangular-shaped voltage generator and the modified constant component 25  $e(t)$  from multiplier 7, is performed. Then, the signal from the multiplier 5 is added in the adder 6 to the carrier signal 26. The received signal 27, which is the corrected high-frequency carrier wave, expressed by the formula  $V_{CM}(t) = k_4 \times V_C(t) \times [1/k_5 + e(t)]$ , from the adder 6 output is sent to the '+' input of the comparator. With the use of the multiplier 5, the adder 6, the multiplier 7, the filter 9, the filter 10, the inverting circuit 11 and the reference voltage source 12, a corrected carrier wave  $V_{CM}(t)$  is generated, by which it is possible to maintain a constant envelope of the audio output signal sent to the loudspeaker device 13. The coefficients in the formulas take the values from the ranges  $k_1 \in <0,5; 2,0>$ ,  $k_2 \in <0,2; 1,5>$ ,  $k_3 \in <0,8; 10,0>$ ,  $k_4 \in <0,2; 1,5>$ ,  $k_5 \in <0,2; 3,0>$  and  $k_6 \in <0,2; 3,0>$ .

The presented system solves the problem of a low coefficient of rejection of influence of supply voltage fluctuations, called the Power Supply Rejection Ratio coefficient (PSRR), when the amplifier has no feedback loop. In this system, in order to increase the Power Supply Rejection Ratio coefficient, signals distorting the source voltage 8 signal are generated without the use of the audio signal. Thus, the audio signal is not modified directly, but indirectly through a modification of a carrier signal. In the presented system, the compensation of the constant component fluctuations takes place through the multiplier 5, the adder 6, the low-pass filter 9, the inverting circuit 11, and the compensation of the variable component fluctuations takes place through the multiplier 5, the adder 6, the high-pass filter 10, the inverting circuit 11 and the reference voltage source 12.

Further figures show the results of a computer simulation of the amplifier. Fig. 2 shows a signal 31 at the output of the power stage with the power supply influence compensation system present. The signal 31 is amplitude-modulated with a variable component of a 3 V amplitude and a

frequency 33 of 1 kHz, while the frequency 32 of the audio signal is 5 kHz and the supply voltage is 27 V. Fig. 3 shows a sinusoidal signal with a frequency 34 of 5 kHz at the output with a load of 8  $\Omega$ .

In turn, fig. 4 shows a signal 37 at the output of the power stage without the power supply influence compensation system present. This signal is also amplitude-modulated by a variable component of a 3 V amplitude and a frequency 36 of 1 kHz, while the frequency 35 of the audio signal is 5 kHz. Fig. 5 shows a sinusoidal signal with a frequency 38 of 5 kHz at the output with a load of 8  $\Omega$ . The envelope of the output wave is visibly modulated and the frequency 39 of amplitude fluctuations is 1 kHz.

Fig. 6 shows a signal 41 at the output of the power stage with the power supply influence compensation system present and with values of voltages changed in comparison with signal 31 in fig. 2. The signal 41 is also amplitude-modulated by a variable component of a 7 V amplitude and a frequency 43 of 1 kHz, while the frequency 42 of the audio signal is 5 kHz and the power supply voltage is 40 V. Fig. 7 shows a sinusoidal signal with a frequency 44 of 5 kHz at the output with a load of 8 $\Omega$ , as well.

Fig. 8 shows a signal 45 at the output of the power stage without the power supply influence compensation system present. The signal, similarly to the one shown above (fig. 5), is amplitude-modulated by a variable component of a 7 V amplitude and a frequency 46 of 1 kHz, while the frequency 45 of the audio signal is 5 kHz. Fig. 9 shows a sinusoidal signal with a frequency 48 of 5 kHz at the output with a load of 8  $\Omega$ . The envelope of the output wave is visibly modulated and the frequency 49 of amplitude fluctuations is 1 kHz.

The compensation system of power supply influence on output audio signal for the class D electroacoustic amplifier, presented above, solves to a significant degree problems of stability of the amplifier, including problems of setting a phase margin.

## CLAIMS

1. A class D electroacoustic amplifier without feedback loop containing a supply voltage source (8), an amplifier low-pass filter (14), a power stage (2) controlled by a pulse width modulated signal, a saw-shaped voltage generator (4) and a comparator (3), to one of which inputs an audio signal is sent, while its second input is connected to the adder (6) of the compensation circuit of supply voltage influence on the output audio signal, to which a voltage from a reference voltage source is sent, characterized in that a low-pass filter (9) and a high-pass filter (10) are connected to the supply voltage source (8), and the reference voltage source (12) is connected to an inverting circuit (11), whose input is connected to the low-pass filter (9) output, while the high-pass filter (10) output and the output of the inverting circuit (11) are connected to a multiplier (7), whose output is connected to the input of another multiplier (5), whose second input is connected to the saw-shaped voltage generator (4), and the multiplier (5) output is connected to one input of the adder (6), whose second input is connected to the saw-shaped voltage generator (4).
2. The class D electroacoustic amplifier, according to claim 1, characterized in that the output signal  $v_0(t)$  of the inverting circuit (11) sent to the multiplier (7) input, which is a modified constant of the supply voltage, is expressed by a formula  $v_0(t) = k_1 \times V_{DCref} / [k_2 \times v_i(t)]$ , where  $V_{DCref}$  is the voltage of the reference source,  $v_i(t)$  is a slow-changing signal on the low-pass filter (9) output, and the coefficient  $k_1 \in <0.5; 2.0>$  and the coefficient  $k_2 \in <0.2; 1.5>$ .
3. The class D electroacoustic amplifier, according to claim 2, characterized in that the output signal of the multiplier (7), which is the error signal  $e(t)$ , sent to the multiplier (5), is expressed by the formula  $e(t) = k_3 \times v_0(t) \times v_{ii}(t)$ , where  $v_0(t)$  is a modified supply voltage constant,  $v_{ii}(t)$  is a fast-changing signal on the high-pass filter (10) output, and the coefficient  $k_3 \in <0.8; 10.0>$ .

4. The class D electroacoustic amplifier, according to claim 3, characterized in that the output signal  $V_{CM}(t)$  of the adder (6), which is the corrected carrier wave signal, sent to one input of the comparator (3), is expressed by the formula  $V_{CM}(t) = k_4 \times V_C(t) \times [1/k_5 + e(t)]$ , where  $V_C(t)$  is a high frequency carrier wave generated by the generator (4),  $e(t)$  is the error signal, and the coefficient  $k_4 \in <0.2; 1.5>$  and the coefficient  $k_5 \in <0.2; 3.0>$ .

5. A method of compensation of supply voltage influence on the output audio signal in an electroacoustic amplifier, which contains a saw-shaped signal generator and a comparator making use of pulse width modulation, and which is powered from a power supply, and to whose input an audio signal is sent, and whose second input is connected to an adder of a compensation circuit of supply voltage influence on the output audio signal, to which a voltage from a reference voltage source is sent, characterized in that from the power supply source (8) a fast-changing signal  $v_{ii}(t)$  and a slow-changing signal  $v_i(t)$  are extracted and then the slow-changing signal  $v_i(t)$  is inverted and multiplied by the value of a reference supply voltage  $V_{DCref}$ , which results in an output signal  $v_o(t)$ , which then is multiplied by a fast-changing signal  $v_{ii}(t)$ , which results in an error signal  $e(t)$ , which then is multiplied by a saw-shaped signal  $V_C(t)$  from the generator (4), and the resulting signal is added to a saw-shaped signal  $V_C(t)$  and as a corrected carrier wave  $V_{CM}(t)$  is sent to one of the inputs of the comparator (3), which makes use of pulse width modulation, and to its second input the audio signal is sent.

6. The method of compensation of supply voltage influence, according to claim 5, characterized in that the output signal  $v_o(t)$  of the inverting circuit (11) sent to the multiplier (7) input, which is a modified constant of the supply voltage, is expressed by a formula  $v_o(t) = k_1 \times V_{DCref} / [k_2 \times v_i(t)]$ , where  $V_{DCref}$  is the voltage of the reference source,  $v_i(t)$  is a slow-changing signal on the low-pass filter (9) output, and the coefficient  $k_1$  takes the values from the range  $<0.5; 2.0>$  and the coefficient  $k_2$  takes the values from the range  $<0.2; 1.5>$ .

7. The method of compensation of supply voltage influence, according to claim 6, characterized in that the output signal of the multiplier (7), which is the error signal  $e(t)$ , sent to the multiplier (5), is expressed by the formula  $e(t) = k_3 \times v_0(t) \times v_{ii}(t)$ , where  $v_0(t)$  is a modified supply voltage constant,  $v_{ii}(t)$  is a fast-changing signal on the high-pass filter (10) output, and the coefficient  $k_3$  takes the values from the range  $<0.8; 10.0>$ .

8. The method of compensation of supply voltage influence, according to claim 7, characterized in that the output signal  $V_{CM}(t)$  of the adder (6), which is the corrected carrier wave signal, sent to one input of the comparator (3), is expressed by the formula  $V_{CM}(t) = k_4 \times V_C(t) \times [1/k_5 + e(t)]$ , where  $V_C(t)$  is a high frequency carrier wave generated by the generator (4),  $e(t)$  is the error signal, and the coefficient  $k_4$  takes the values from the range  $<0.2; 1.5>$  and the coefficient  $k_5$  takes the values from the range  $<0.2; 3.0>$ .

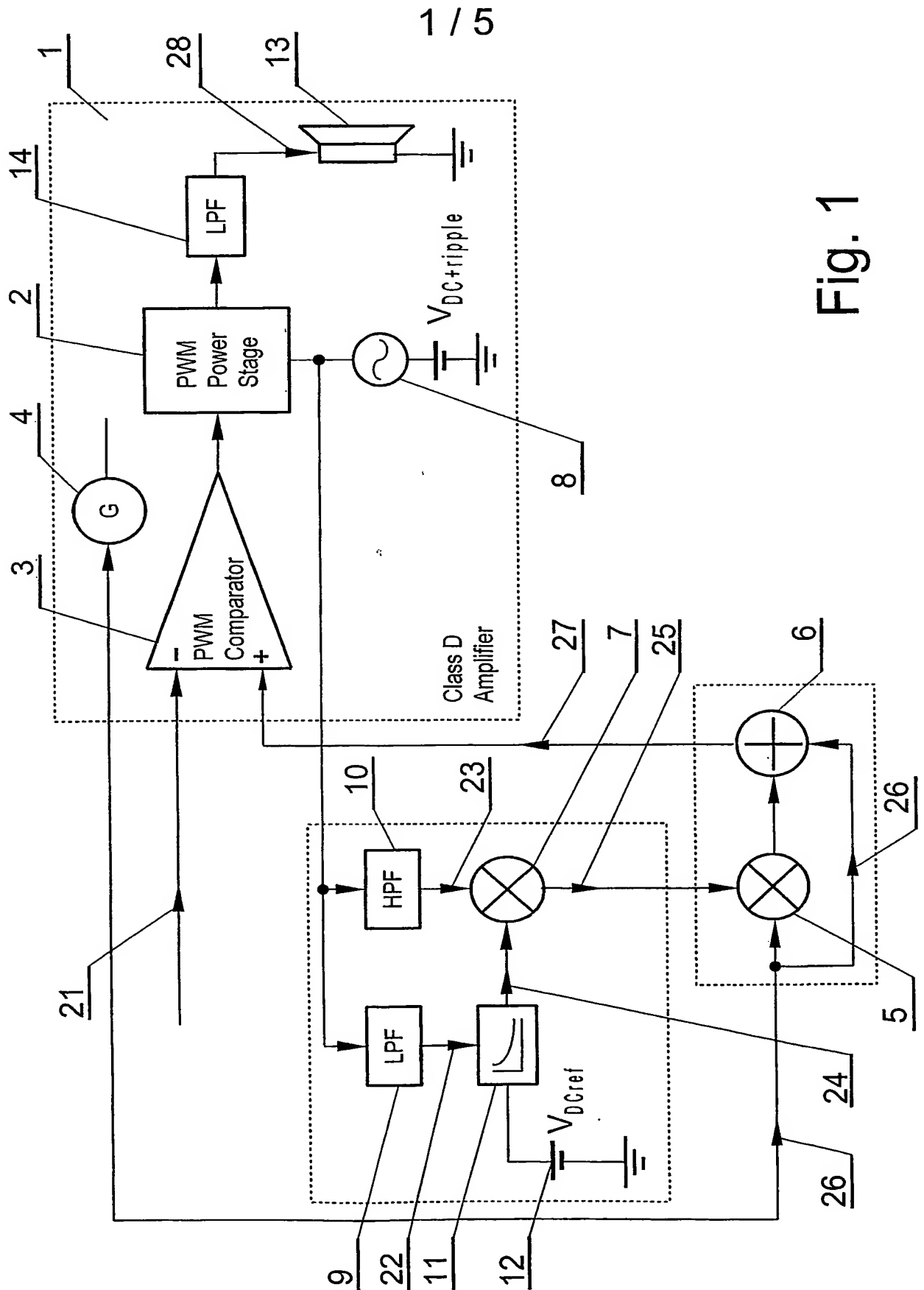


Fig. 1

2 / 5

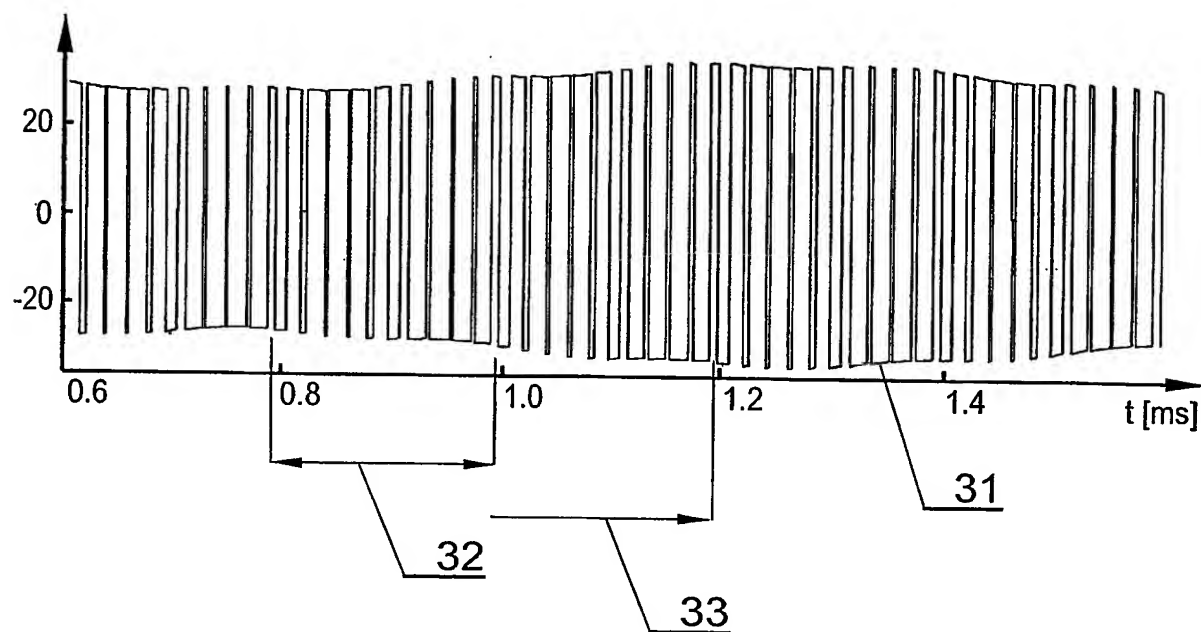


Fig. 2

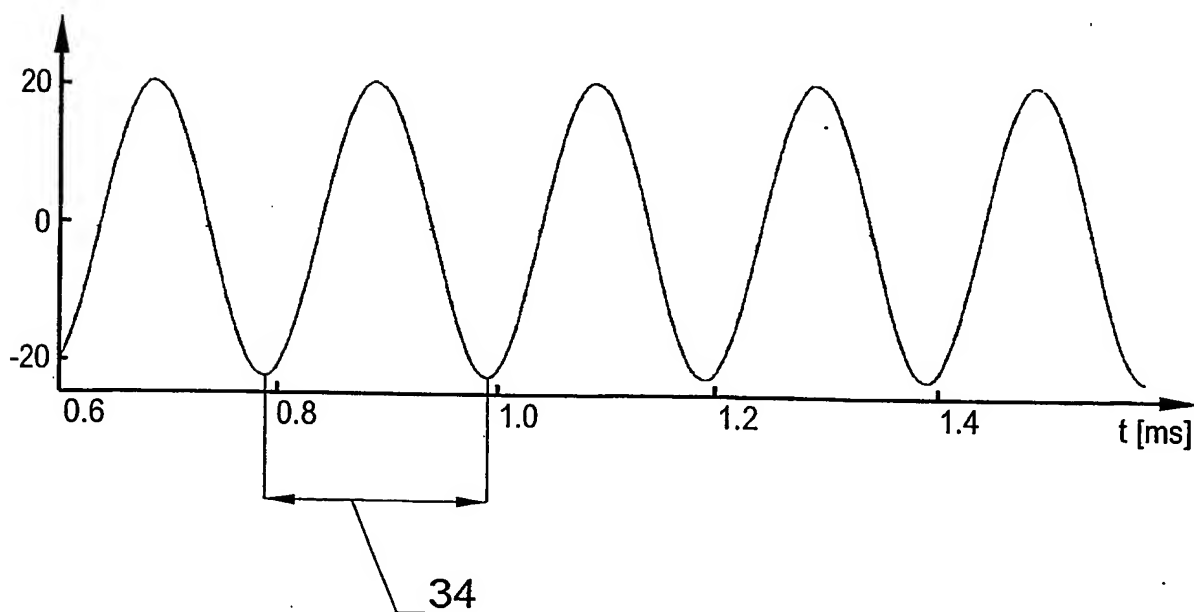


Fig. 3

3 / 5

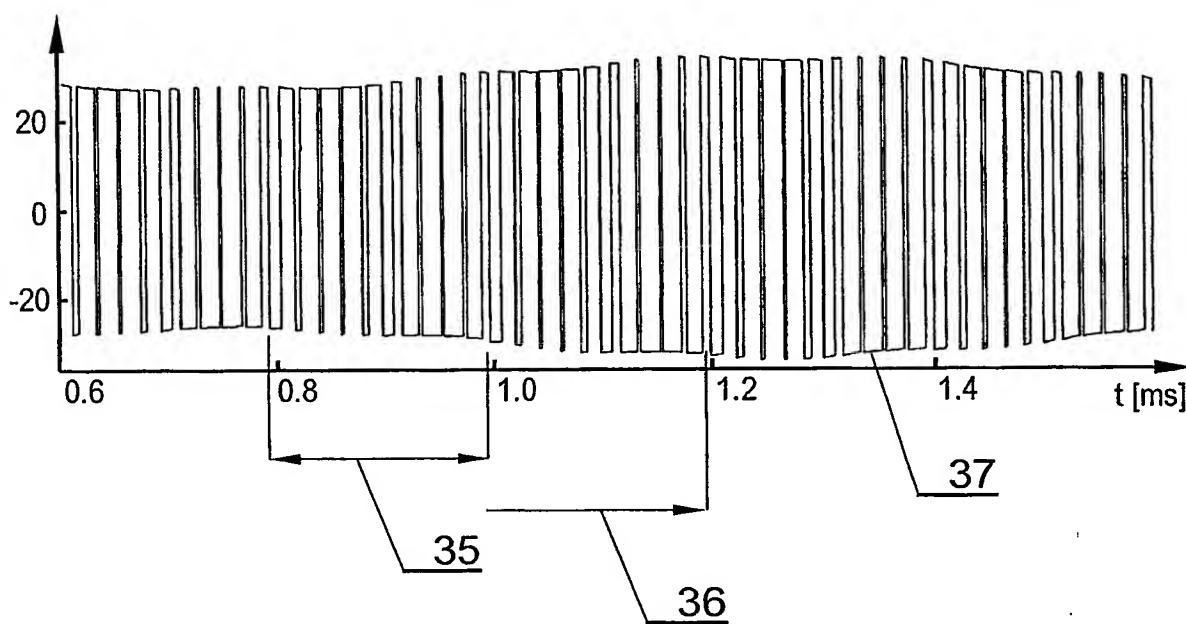


Fig. 4

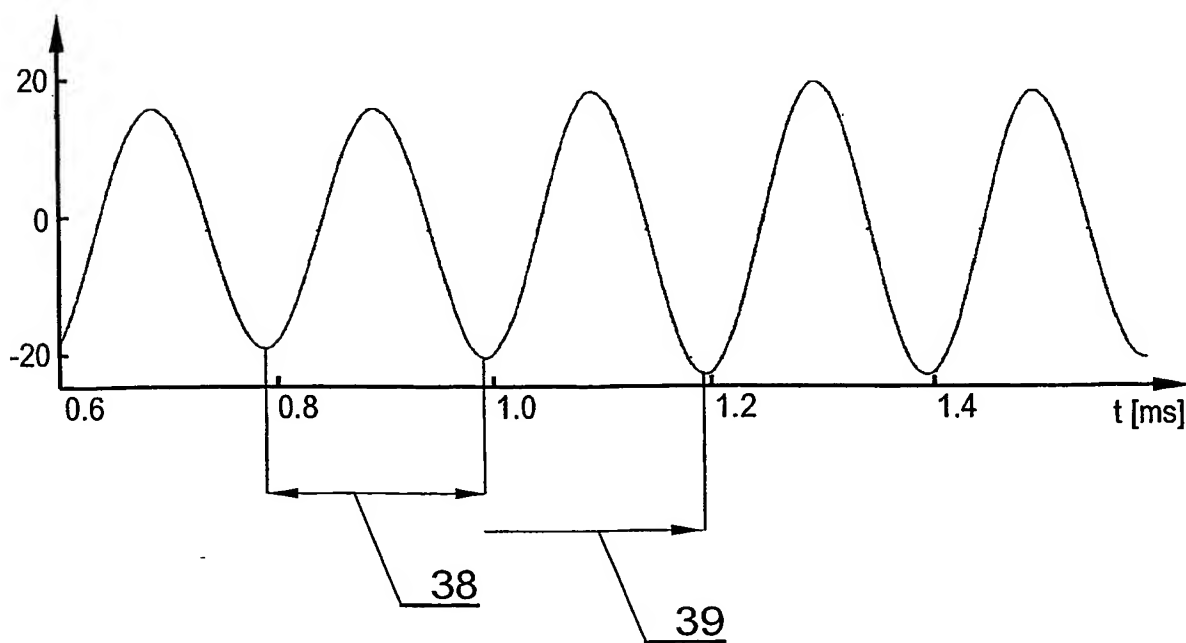


Fig. 5

4 / 5

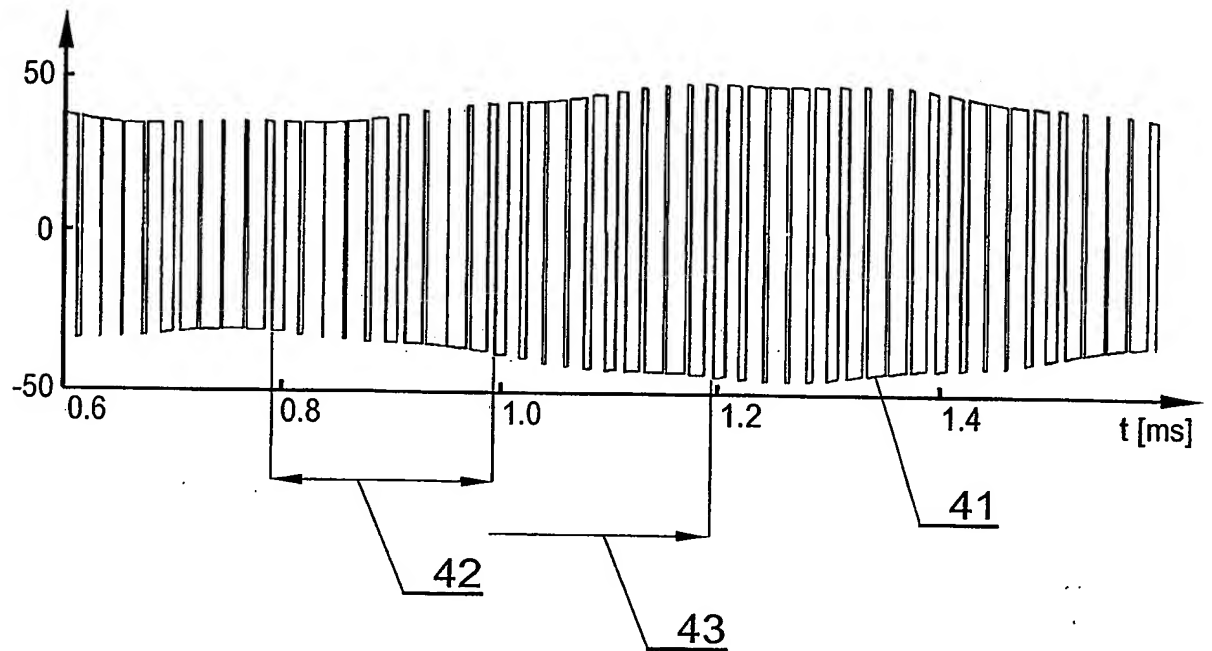


Fig. 6

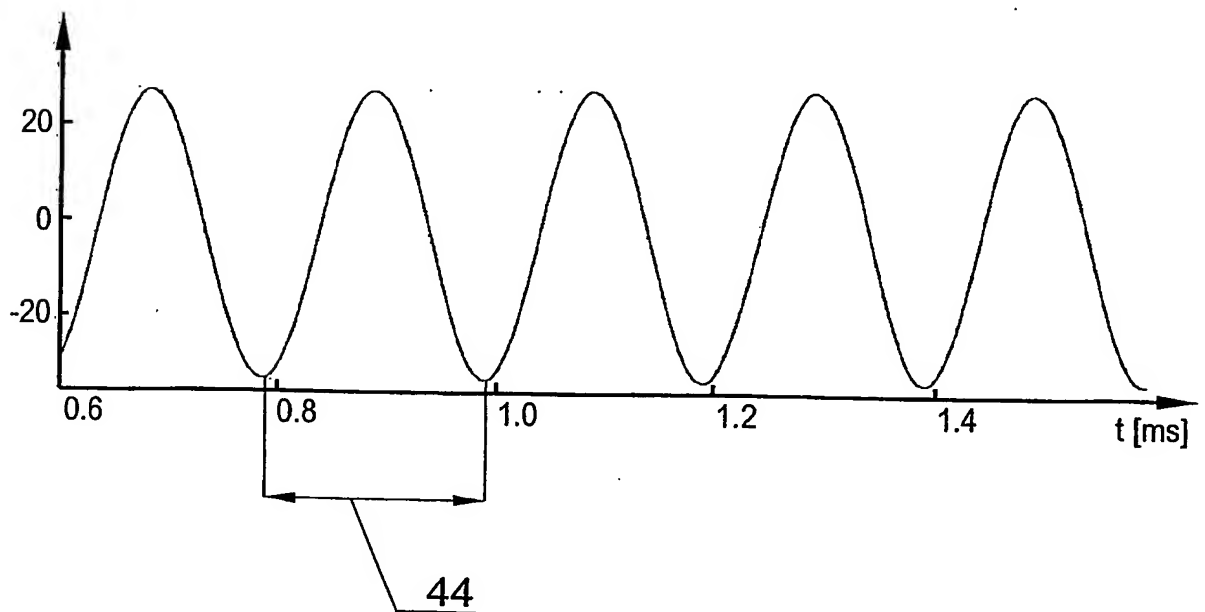


Fig. 7

5 / 5

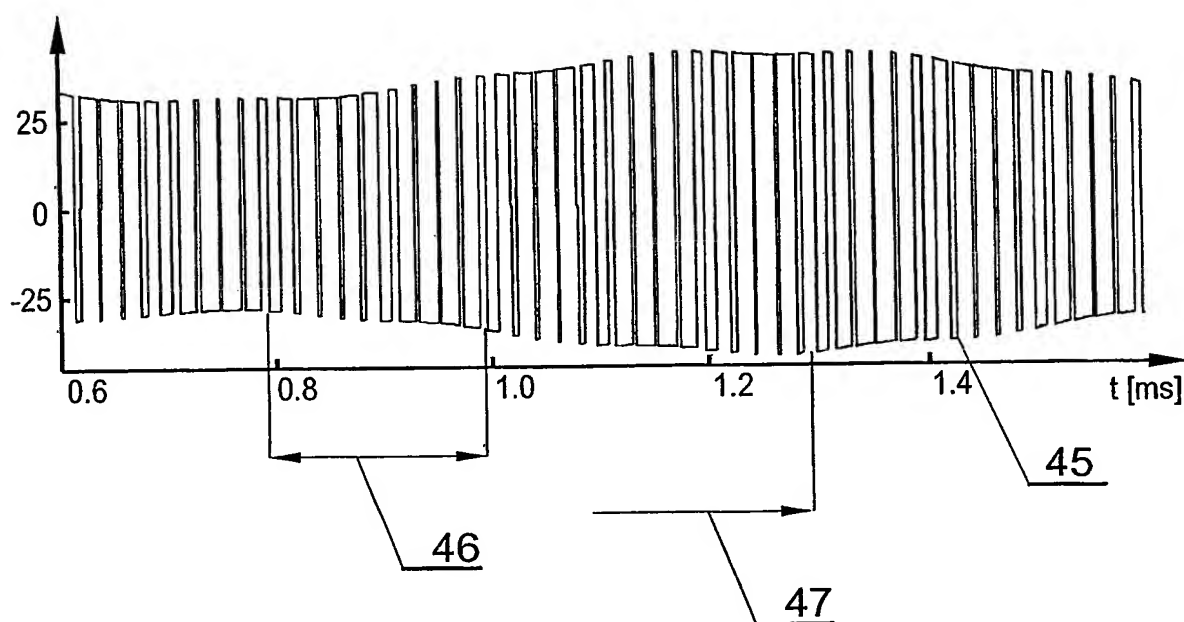


Fig. 8

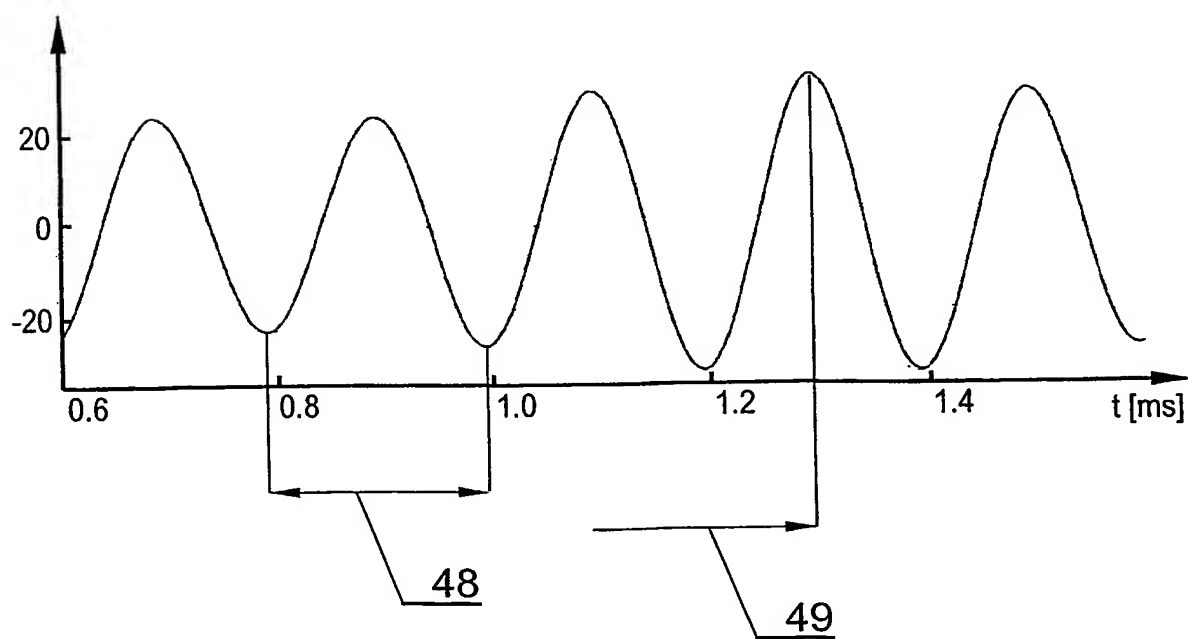


Fig. 9

## INTERNATIONAL SEARCH REPORT

 Interna' Application No  
 PCT/PL 03/00006

 A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 7 H03F3/217

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H03F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 559 467 A (SMEDLEY KEYUE M) 24 September 1996 (1996-09-24) abstract	1
A	US 5 262 733 A (NAKAJIMA YASUFUMI ET AL) 16 November 1993 (1993-11-16) abstract; figures 1,3	1
A	HANCOCK J: "A CLASS D AMPLIFIER USING MOSFETS WITH REDUCED MINORITY CARRIER LIFETIME*" JOURNAL OF THE AUDIO ENGINEERING SOCIETY, AUDIO ENGINEERING SOCIETY. NEW YORK, US, vol. 39, no. 9, 1 September 1991 (1991-09-01), pages 650-662, XP000226144 ISSN: 0004-7554 paragraph '01.1!; figure 1	1

-/--

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

## \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\*&amp;\* document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 June 2003	27/06/2003
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer  Agerbaek, T

## INTERNATIONAL SEARCH REPORT

Internati plication No

PCT/PL 03/00006

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 160 896 A (MCCORKLE DAVID P) 3 November 1992 (1992-11-03) abstract; figure 2 -----	1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

**INTERNATIONAL SEARCH REPORT**  
information on patent family members

International Application No  
**PCT/PL 03/00006**

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5559467	A	24-09-1996	NONE	
US 5262733	A	16-11-1993	JP 4281606 A	07-10-1992
			DE 69229973 D1	21-10-1999
			DE 69229973 T2	27-04-2000
			EP 0503571 A1	16-09-1992
US 5160896	A	03-11-1992	DE 69318054 D1	28-05-1998
			DE 69318054 T2	13-08-1998
			DE 69330355 D1	19-07-2001
			DE 69330355 T2	20-09-2001
			DK 776088 T3	24-09-2001
			EP 0557032 A2	25-08-1993
			EP 0776088 A2	28-05-1997
			JP 3366677 B2	14-01-2003
			JP 6216664 A	05-08-1994
			JP 2003078363 A	14-03-2003

Form PCT/ISA/210 (patent family annex) (July 1992)

